

III. *Part of a Letter from Mr Lewenhoeck, concerning the circulation and globules of the Blood in Butts.*

Delph in Holland, July 9. 1700.

DURING this Winter, I have often observed the Boys looking for small living Butts in the Smelts that are sold just by my House, in order to throw 'em into water, and entertain themselves with beholding the uncommon motion of that little Fish when it swims, as being different from that of all other Fishes.

This put it in my head to look more narrowly into those little Fishes, some of which were so small, that the whole Body, bating the Tail, was no longer than an inch.

Having often examin'd 'em with a Magnifying-glass, in order to see the circulation of the Blood, (with which I am much delighted) and the variety of its motion, not only for my own satisfaction, but that of several Learned Gentlemen, to whom I shew'd the same, my thoughts were again pointed upon those little particles which entitle the Blood to its red colour, which I formerly asserted to be flat and oval.

The greatest motion of the Blood observable thro the Fins, was on each side of the many little single Bones plac'd among the Fins; where the Blood vessels were so large, that twenty five of the above-mention'd particles could pass in a Breast; but dwindled as they drew nearer to the extremity of the Fins, small Vessels being all along detach'd from the Arteries.

On one side of a little Bone runs an Artery, and on
the

the other a Vein, corresponding to it; and besides, I saw a Vein and an Artery lying so close together, as if their coats had been united.

From the above-mention'd Artery, smaller Vessels arise across the Membrane between the little Bones, and when they've run out the breadth of three or four hairs, are again united in one Vein.

These small Vessels receive about two or three particles of the Blood at once, especially if the Fish lies still, and consequently its little Bones close one to another. If it exercises its little Fins in swimming, the distance between the little Bones are enlarged, the interjacent Membranes stretch'd out, and the Blood Vessels that run across them, especially those in the Tail-fin, are drawn out so as to be above twice as long as before.

I found it very easy to extend the Tail-fin, and accordingly having stretch'd it to a breadth equal to what the Fish gives it in the swimming motion, in order to observe the motion of the Blood in the thus extended Vessels, I found that, whereas, when the Fish did not move, the small Vessels receiv'd two or three particles in a Breast; the same Vessels now stretch'd out along with the Tail-fin which they run across, not only admit no more than one particle, but likewise the particles do not move so fast as in the extended Vessels; and in some places these very particles are so disjoin'd, that one or two particles may lye in the Intervals.

In this observation, I could not find that the particles were perfectly oval, but met with 'em sometimes round, and sometimes in a shapeless figure. The occasion of which, to my mind, is this: The little Vessels being stretch'd to an unwonted length, become narrower, and by consequence the particles being very pliant, are press'd and squeez'd out of their circular form.

To satisfy my self further, I cut off a piece of the Tail from several little Butts, in order to view the Blood out of the Vessels: For I was not satisfy'd that the particles in the Blood of Fishes were naturally oval; nay, I rather fancy'd that in their perfect state they'd come nearer to a round than an oval form; going upon this position, that the Blood of Fishes consists of six little globular Bodies making up the particles, as well as that of men and other Animals; for I could observe several Particles broken in 4, 5, and some few in six pieces; and, what I look'd upon as very remarkable, I saw oval, and other figures become roundish, and at last perfectly round.

To trace the matter further, I took the Blood running from a living Salmon, when it is cut in pieces, and put it into a Glass tube not larger than a small Quill.

In a short time the Blood in the tube congeal'd, but when it became partly fluid again, I put it into a smaller Glass tube, and having plac'd it before my eye, the particles being in motion, appear'd some of 'em flat oval; and others, which presented themselves to the eye sideways, seem'd a little thick, and those whose side did not directly face the eye, seem'd a little broader, without the least appearance of any globular form.

The Blood of a Salmon appears blackish, by reason of a greater number than ordinary of the redning particles.

I put some of the same Blood upon a very clean Glass, and where the particles lay thin, perceiv'd 'em oval, nay, in several ovals I descri'd little Globes, and in some few, particularly six Globes.

Where these little globular Bodies were crowded in upon one another, the particles of the Blood were congeal'd together, so that no ovals could be discern'd; nay,

may, the particles seem'd to be huddl'd up together so as that six of 'em had made a compound Body.

I pursu'd this new Inquiry so far, by reason that I had been for some time concern'd, as if in some former Essays of this nature I had been guilty of a mistake, in making the particles of the Blood of Fishes to be round, and not oval, since all that look'd upon 'em with my Glasses took 'em to be such.

I've formerly said, and do still affirm, that I have seen the Blood circulate in Vessels so small, that if a particle of Sand were divided into ten hundred thousand parts, one of these little parts could not pass the Blood-vessel, tho' twere to be suppos'd to be as pliable as a particle of Blood.

I tried all possible means to discover the oval particles of Blood, when it circulates freely in the Veins; and for that end pitch'd upon the smallest Blood-vessels; but notwithstanding the nicest enquiry I could make, I could not satisfy my self upon the point: for sometimes I met with an obscure dark particle, sometimes with a much clearer one; and when I cast my eye upon the smallest Vessels in which the Blood did not move, and several Vessels that I discover'd upon the extremity of the Fins, the particles were quite undone, so that I saw nothing but a simple stagnating Liquor, which was a little tinctur'd with a bilious colour.

Heretofore the oval particles of the Blood in Fishes, were delineated by the Engraver, according to my orders, without seeing them himself; and I likewise mix'd the blood with water, by reason that various redning particles hinder a nice view: But for further satisfaction both to my self and others, I've this time given the Engraver the Magnifying-Glass, with the blood of the Salmon upon it, that he may design 'em more exactly according to their appearance to his own Eyes.

Fig 2. A B C D represents the oval particles of the Blood of a Salmon that weighed above thirty pound.

A B represents the particles that appeared flat and broad, but did not face the eye directly.

Those about C came strait upon the eye, and for the most part had a little clear sort of a light in the middle, larger in some than in others, which the Engraver has done his utmost to imitate.

These particles are heavier than the (so call'd) ferrous Liquor, in which they swim; and which together with the particles constitutes the Blood: Upon which account I ordered it so, that the particles of the Blood sinking downwards very slowly, gave the Engraver the opportunity of seeing thousands of them falling gradually to the bottom.

Had I gone immediately to work, and design'd 'em my self according to my own sight, I had made them twice as big as they are, from whence we may gather the difference between the eye of one man and that of another.

I likewise put upon a magnifying Glass the Blood of a very small Butt, which was not mix'd with any Liquor, only the particles lay in their own juice, which is called the Serum or Whey of the blood.

These last mention'd particles are represented fig. 3. between E and F.

Tho these last particles are designed smaller than the first, yet it must be understood, that I could not observe any difference in their Bulk; and I am firmly perswaded there is no difference in the bulk of the blood particles, so that the red making in the blood particles in a Whale, are not to be supposed greater than those in a small Fish.

I likewise placed these particles of the Blood of a little Butt, pasted upon a clean Glass, before a Magnifying Glass, where they stand magnified to the above-mention'd degree ; in order to be capable to oblige any Gentleman with the sight, tho' twere on the cloudiest day in Winter, without any artificial light.

These particles which are distinguished by little shining spots in the middle, are delineated fig. 4. betwixt G and H.

Moreover, I put the blood upon the Glass to a greater Magnifying Glass, the thinner moisture arising from the (so called) serous matter, and the oval-like Blood being exhal'd ; so that some small oval particles were to be seen, that were so far from running together, that they did not touch one another, and plainly discover'd themselves to consist of six little globular particles, which the designer has imitated, to the utmost of his power, in fig. 5. between I and K.

In pursuance of this new Observation, I apply'd myself to view the circulation of the Blood with Glasses, more magnifying than any I have yet used ; which at last I have fully compleated ; as well as the evidence of the oval particles. Now the greater the magnifying Glass is, the swifter does the circulation of the Blood appear in the Vessels. Having retarded this motion, I imploy'd two or three seconds of time in observing the little Veins, and found that in several small Vessels the oval particles were so undone, that I could neither see them nor those of which six had made up a particle of Blood ; but only a simple fluid matter, with a faint colour running along the Vessels ; but in a large Artery at the Tail, the Blood mov'd so slowly, that I could easily discern that the particles in that Vessel were oval ; nay, not only so, but I likewise perceived more clearly than before, the little Globes,

that make up the oval particles, if not always, at least for the most part.

'Tis easie to conceive how six little globes, which are pliant and always in motion, and driven one upon another, should settle entirely in the fashion of a bowl. Thus Fig. 6. represents the first coalition of the six little bullets into one, five of which are presented to our view, and the sixth withheld from the same.

I have made up such a globe as is represented in fig. 6. of six Wax bullets put together, in order to shew them to those who enquire narrowly after the form and composition of the little globular particles of the blood; adding withal, that I am certain each of these little globes is at least compounded of six and thirty others.

These little bullets being mov'd and squeez'd together, and being at the same time pliant, and pack'd up into one compleat round form, represented fig. 7.

From such a Scheme we may conceive how the globular parts of the blood of man and other animals acquire a roundness; but how the oval particles are compounded of the six globes is not easily apprehensible.

I have asserted formerly, that every one of the little globes, six of which make up one globe, does consist of 6 other globes; and the more we divide such a globe of blood by our imagination into smaller and smaller parts, the little parts that enter into the composition will still be unconceivably lesser. I've wonder'd to hear some offer to trace such things to the first beginning; for my part, supposing I could discover the figure and shape of parts lesser than a globe of blood by a thousand millions, I should still be far from reaching the first constituent parts.

As I asserted above, that the particles of blood are by a pressure so disjoin'd, and united with the fluid matter in which they move, that the whole appears as a simple moisture ; so we may easily imagine, that when a horse strains, and presses his breast in drawing a heavy load, the globes of blood are undone, and taken down in the midst of the vessels where the greatest pressure comes, and as it were confounded or united with the fluid matter, call'd by Artists *Serum*.

I have also bethought myself, that perhaps the undone particles, when freed from the above-mention'd straining, may return to their former figure, just as when a piece of the fat of an Ox or Sheep is laid in such a heat, that its particles, which come very near to the globes of the blood, are undone by the fire, and turn into a clear crystalline liquor, visible by a Magnifying-Glass : So soon as the melting heat is gone from the fat, it presently returns to its former globular parts, and this will happen whenever it is cold again, tho ye melt it ten times or oftner.

I have often fancy'd, and been fully perswaded, that no venous blood could become arterious, without being first in the heart : But forasmuch as the contrary appear'd to me in one of my Experiments, which I made purely for my own diversion, I have a strong mind to give an account of the same.

These blood-vessels are design'd a little larger than they appear'd to me ; and in the middle of the small vessels a small space is left white, which otherwise the particles of blood would alter, to the end that the motion of the blood may be the better perceiv'd.

Let us imagine A B in fig. 8. to be a vein, in which the blood (look'd upon thro a Magnifying-Glass) passes with great celerity from B to A.

Out of this vein run two little branches, *v. z.* C and D. which unite between E and F.

Now

Now suppose H I to be an artery, in which the blood moves upwards with equal swiftness from H to I.

Out of H I arises a venous Spring, delineated in K, F, L.

The blood moving from K to F, joyns the other in F; and by this means part of the blood coming from the artery is thrown into the vein, as passing from F to G; and to the best of my observation, a quantity of blood, just equal to that carried from K F to G, moves from C E to F, and directs its course upwards from F to L: so that whatever arterious blood passes thro F K and F G, an equal quantity of venous blood passes back thro C E and F L.

Tho the delectable variety of the blood's motion was formerly apparent, yet this experiment pleas'd me beyond the others, by reason that it afforded me a very clear perception of the above-mention'd variety, and besides this union of the blood vessels was not formerly come to light.

'Twas several years that I had not seen the seed of a Cock; and now the thought being come into my head, I view'd the seed of two several Cocks that were not yet arriv'd at their full growth; in order to trace, as much as possible, the length and singular narrowness of the tails of the little animals in the male seed. But I could not compass my end, notwithstanding I try'd 'em sometimes living, and sometimes dead. However, I am certain that the least of the tails of those animals is more than 10000 times smaller than one hair upon my hand; tho I cannot say that I saw it distinctly.

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fig: 7.



fig: 6.

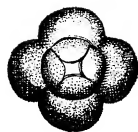


fig: 5.



fig: 4.



fig: 3.



fig: 2.

fig: 8.

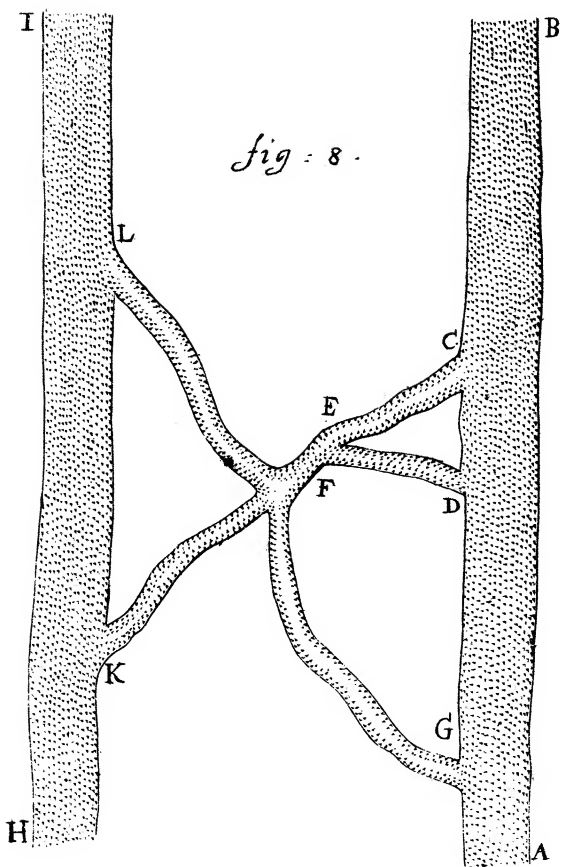


fig: 1.

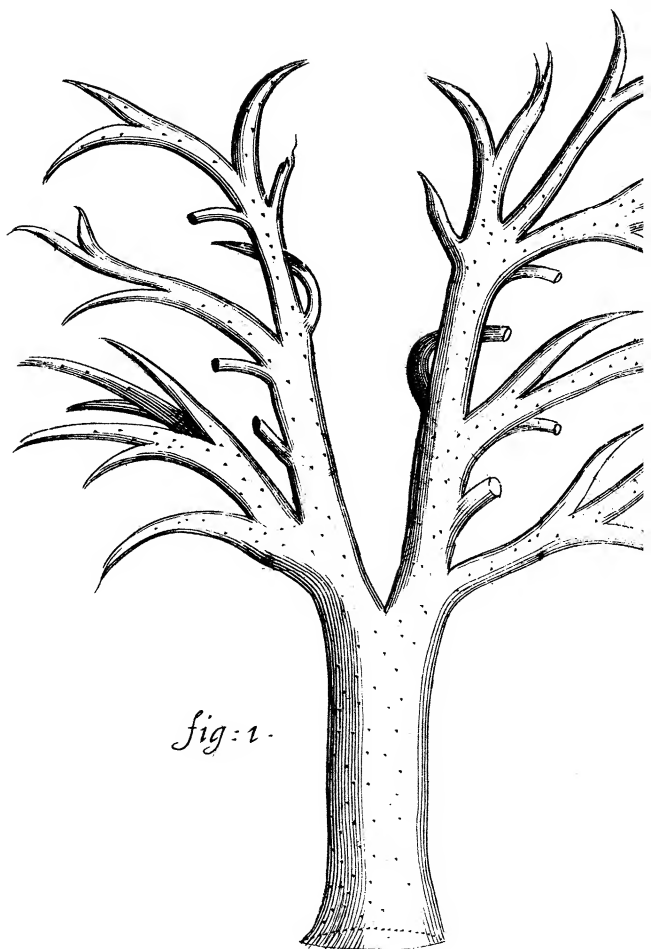


fig. 2.

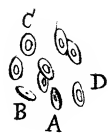


Fig. 1



Fig. 2



Fig. 3



Fig. 4



Fig. 5



Fig. 6

